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Nagaoka et al.

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(54) **ACTUATOR UNIT AND DOOR LATCH DEVICE PROVIDED WITH ACTUATOR UNIT**

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CPC ***E05B 81/14*** (2013.01); ***E05B 81/06*** (2013.01); ***E05B 81/16*** (2013.01); ***E05B 81/30*** (2013.01); ***E05B 81/42*** (2013.01); *Y10T 292/108* (2015.04)

(58) **Field of Classification Search**
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USPC ..... 292/201, 216, DIG. 23, 279, 280
See application file for complete search history.

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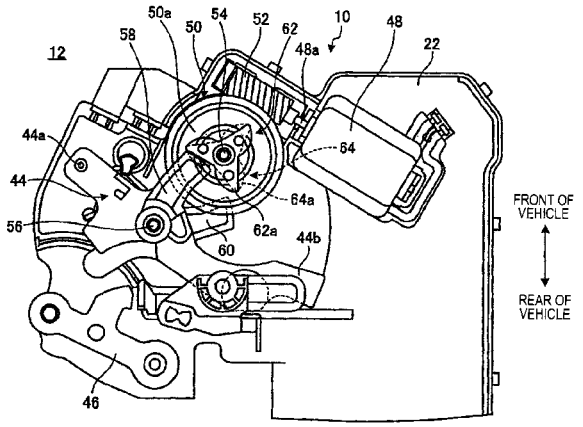
(57) **ABSTRACT**

When a worm wheel is in a first stop position a locking surface of a first projecting portion and a locking surface of a second projecting portion, which is provided back to a pressing surface of a first projecting portion adjacent to the locking surface of the first projecting portion, are situated along concentric arc-shaped rotational loci of the rotational end faces of a first engagement arm and a second engagement arm, while when the worm wheel is in a second stop position a locking surface of the second projecting portion and the locking surface of the first projecting portion, which is provided back to a pressing surface of the second projecting portion adjacent to the locking surface, are situated along the concentric arc-shaped rotational loci of the rotational end faces of the first engagement arm and the second engagement arm.

5 Claims, 7 Drawing Sheets



(51) **Int. Cl.**

E05B 81/06	(2014.01)
E05B 81/16	(2014.01)
E05B 81/30	(2014.01)
E05B 81/42	(2014.01)
E05C 3/16	(2006.01)

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FIG. 1

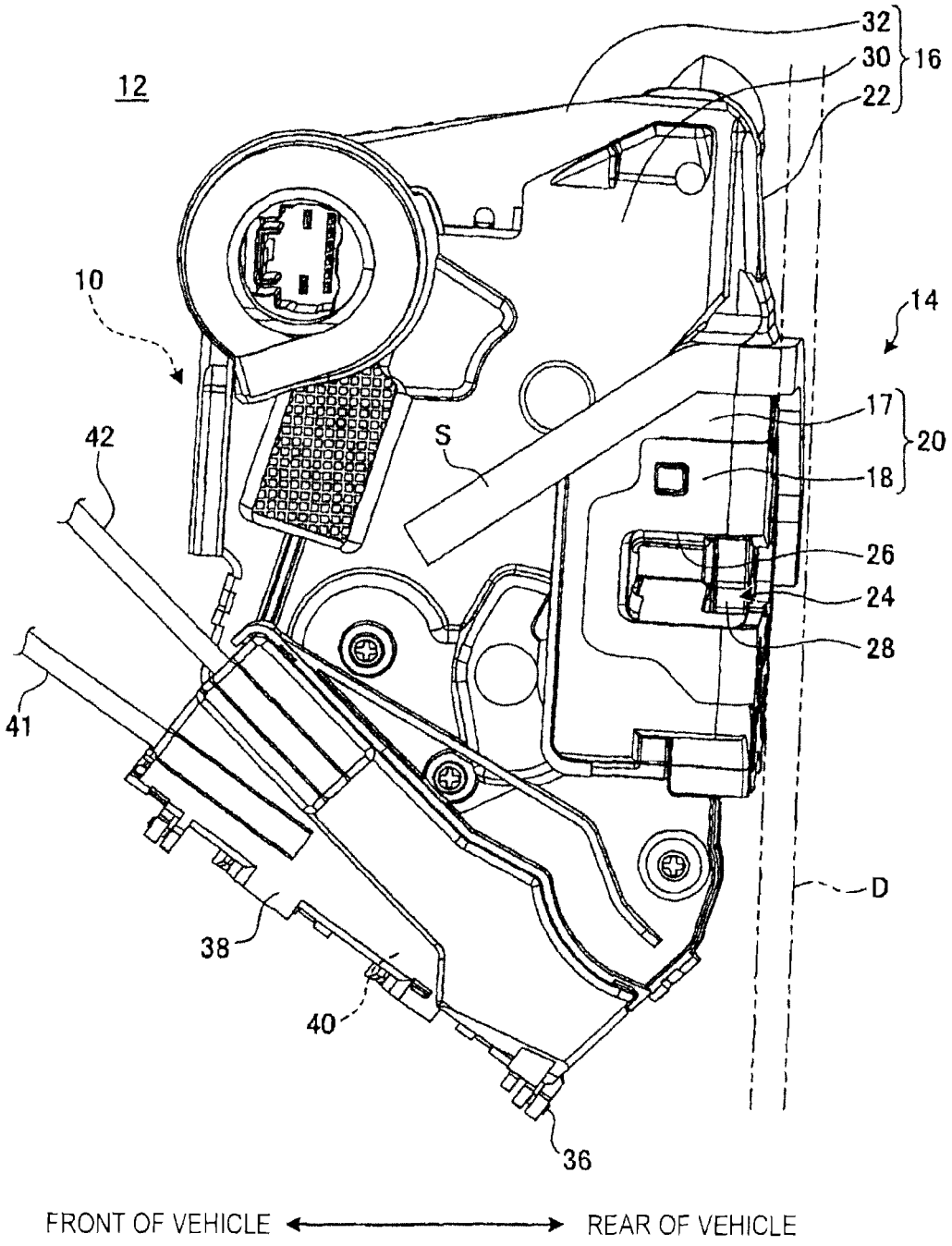

12
10
32
30
16
22
14
17
20
18
S
42
26
24
28
41
D
38
40
36
FRONT OF VEHICLE
REAR OF VEHICLE

FIG. 2

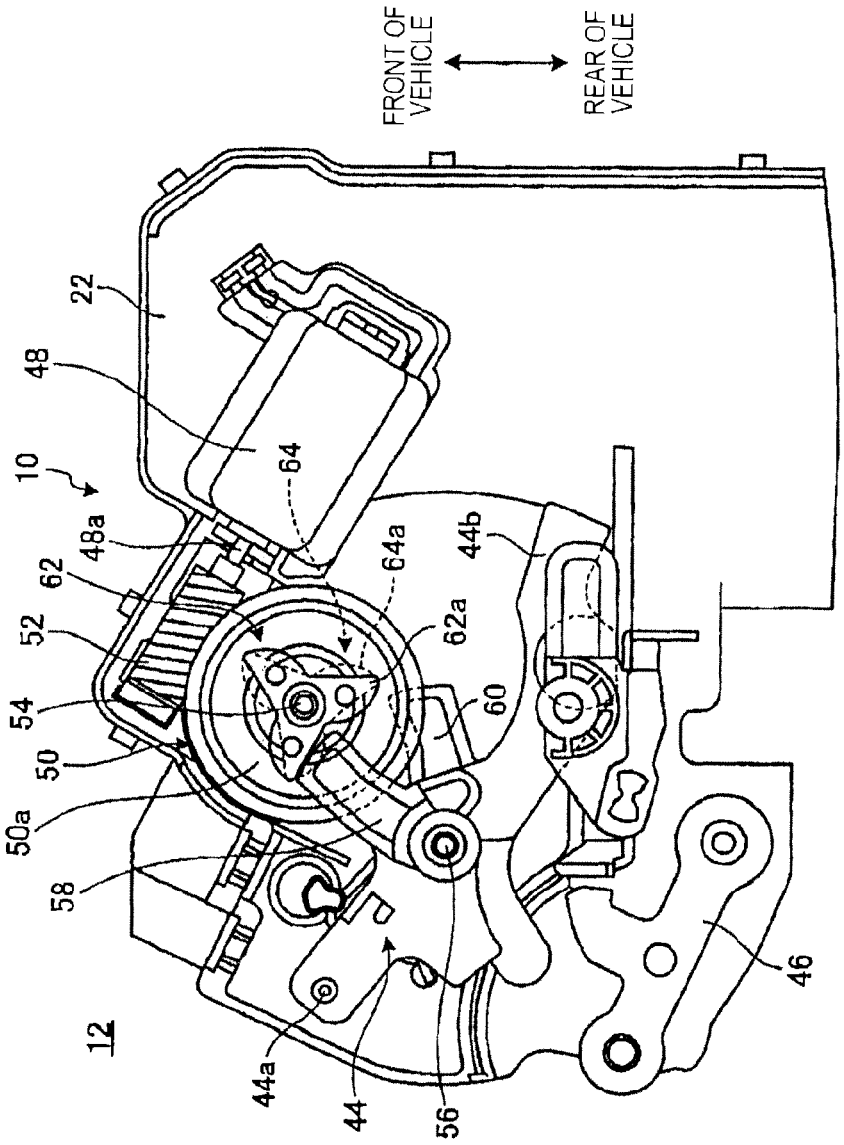
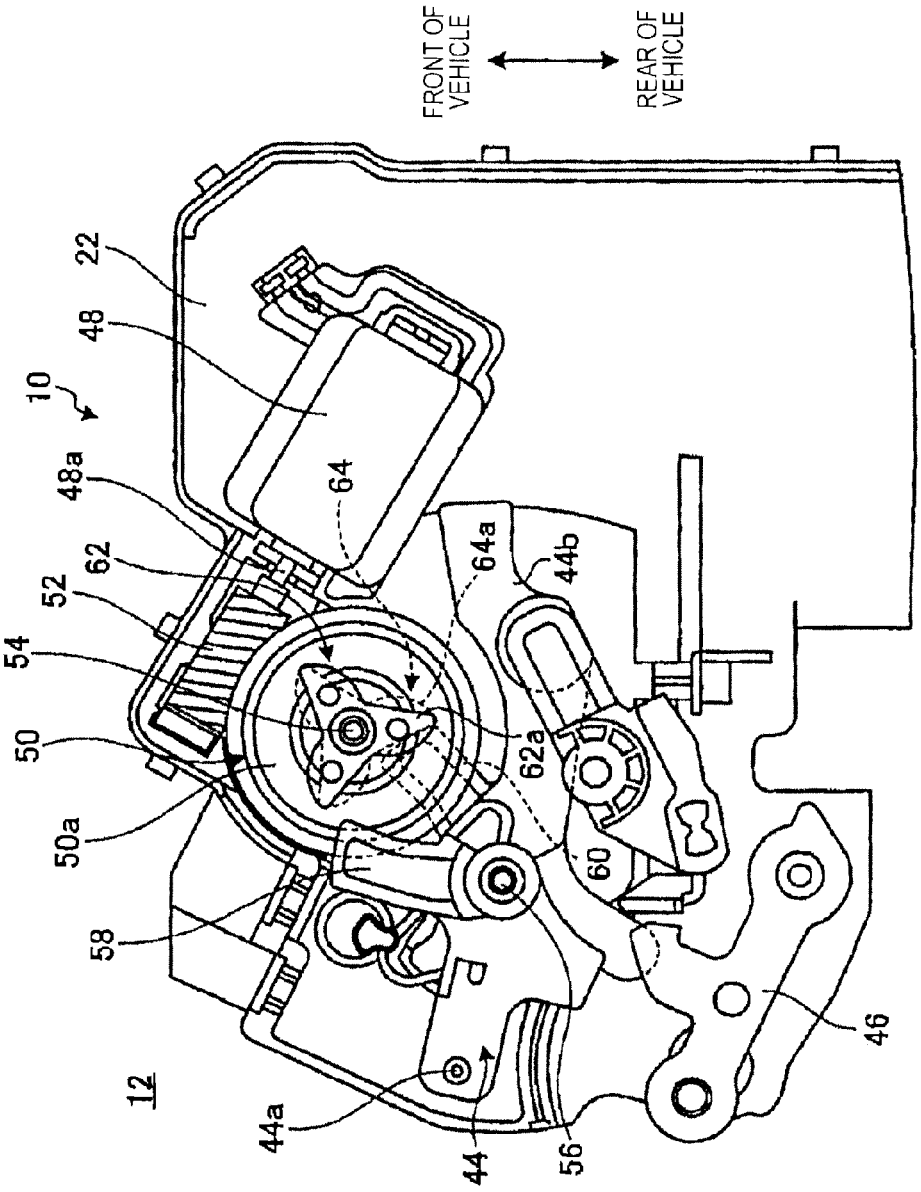

FRONT OF VEHICLE
REAR OF VEHICLE
22
48
10
64
48a
64a
44b
62
62a
52
54
60
50
50a
58
46
12
44a
44
56

FIG. 3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REAR OF VEHICLE
22
48
10
48a
64
64a
44b
62
52
54
50
62a
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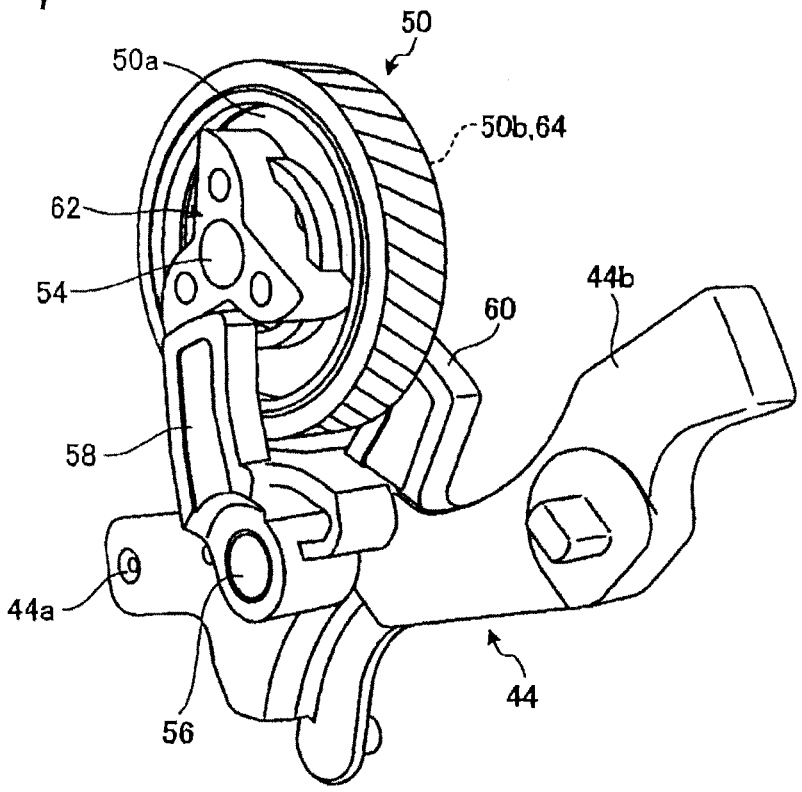
60
58
46
12
44a
44
56

FIG. 4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62
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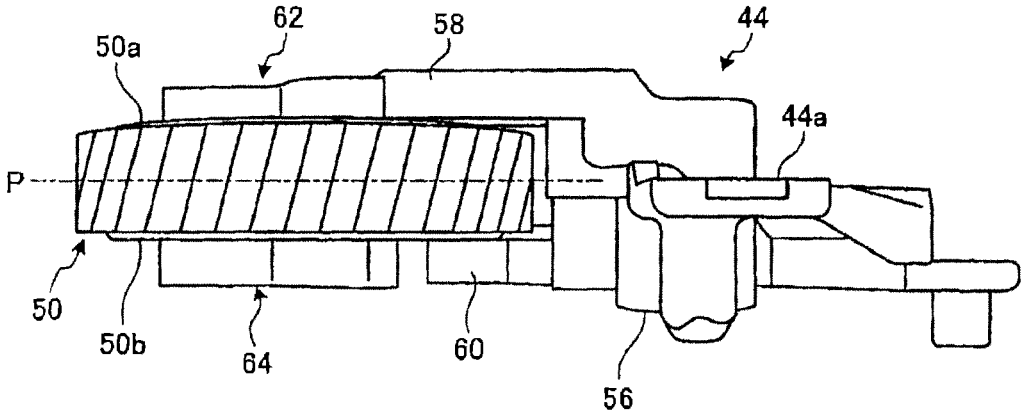
44a
56
44

FIG. 5


62
58
44
50a
44a
P
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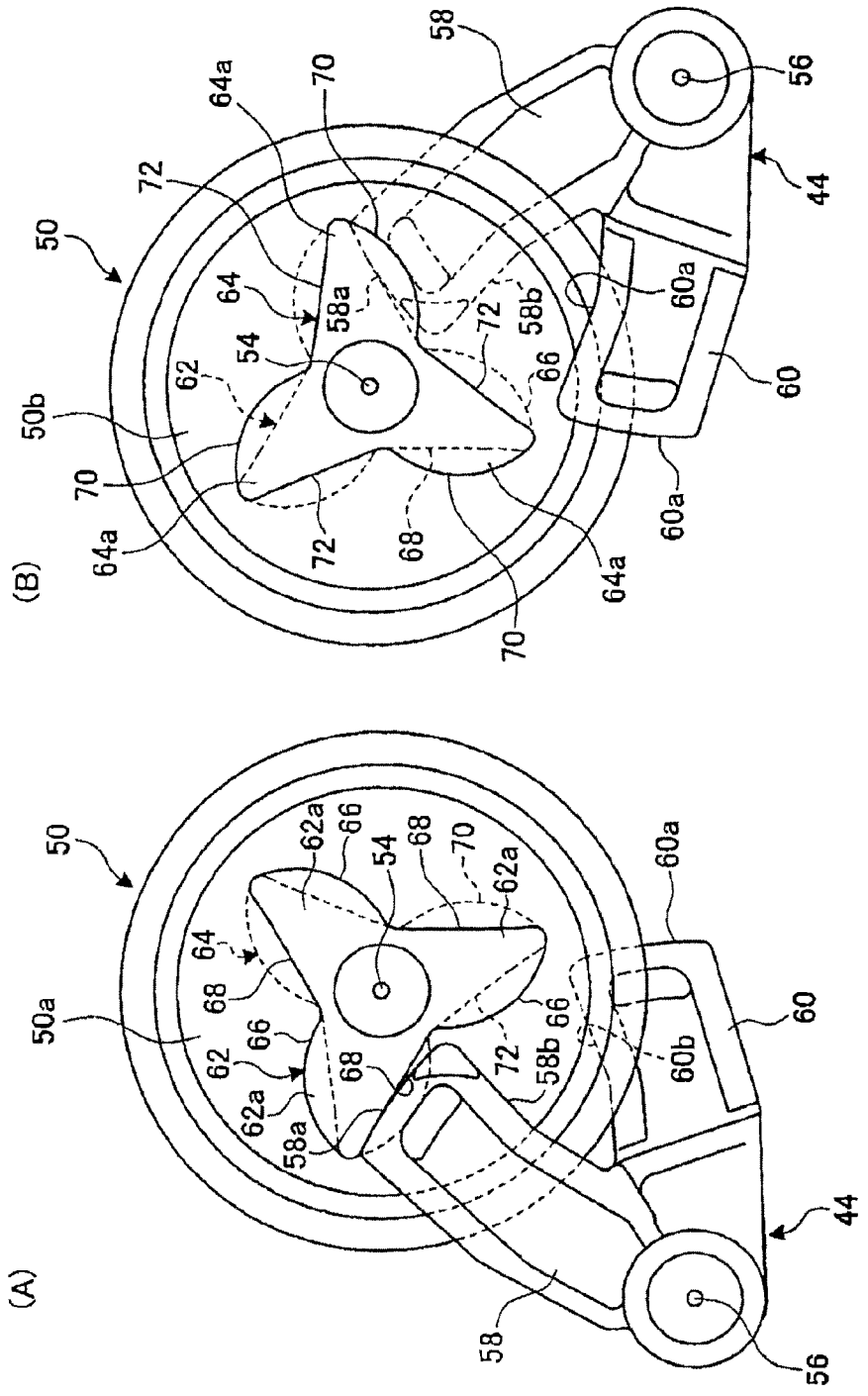
50b
64
60
56

FIG. 6


(B)
58
56
64a
70
72
44
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64
58a
58b
60a
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50b
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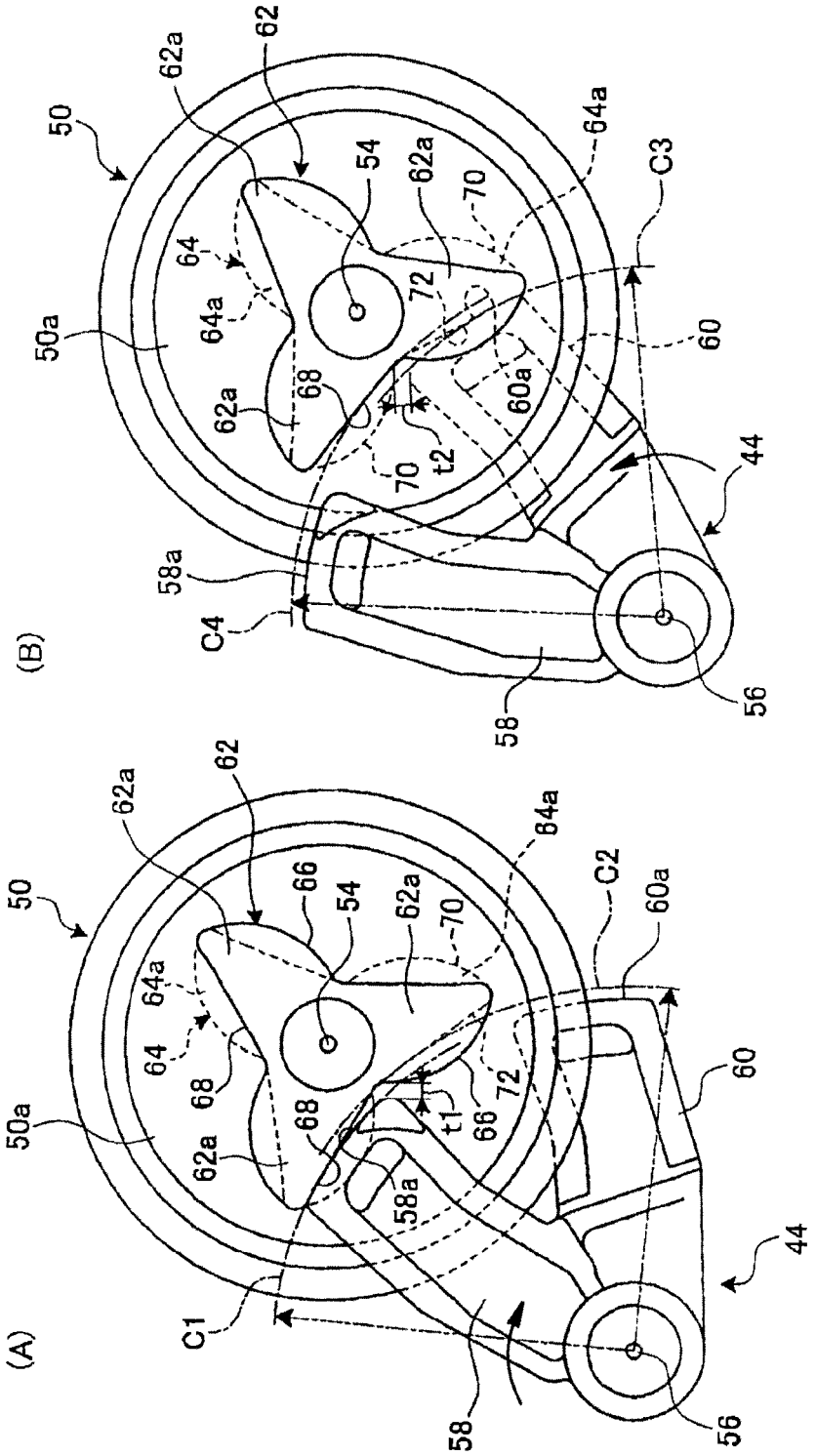
64a
72
68
64a
60a
70
(A)
50
62a
66
54
68
70
62a
60a
64
68
60
50a
66
62
66
72
58b
60b
68
62a
58a
44
58
56

FIG. 7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(B)
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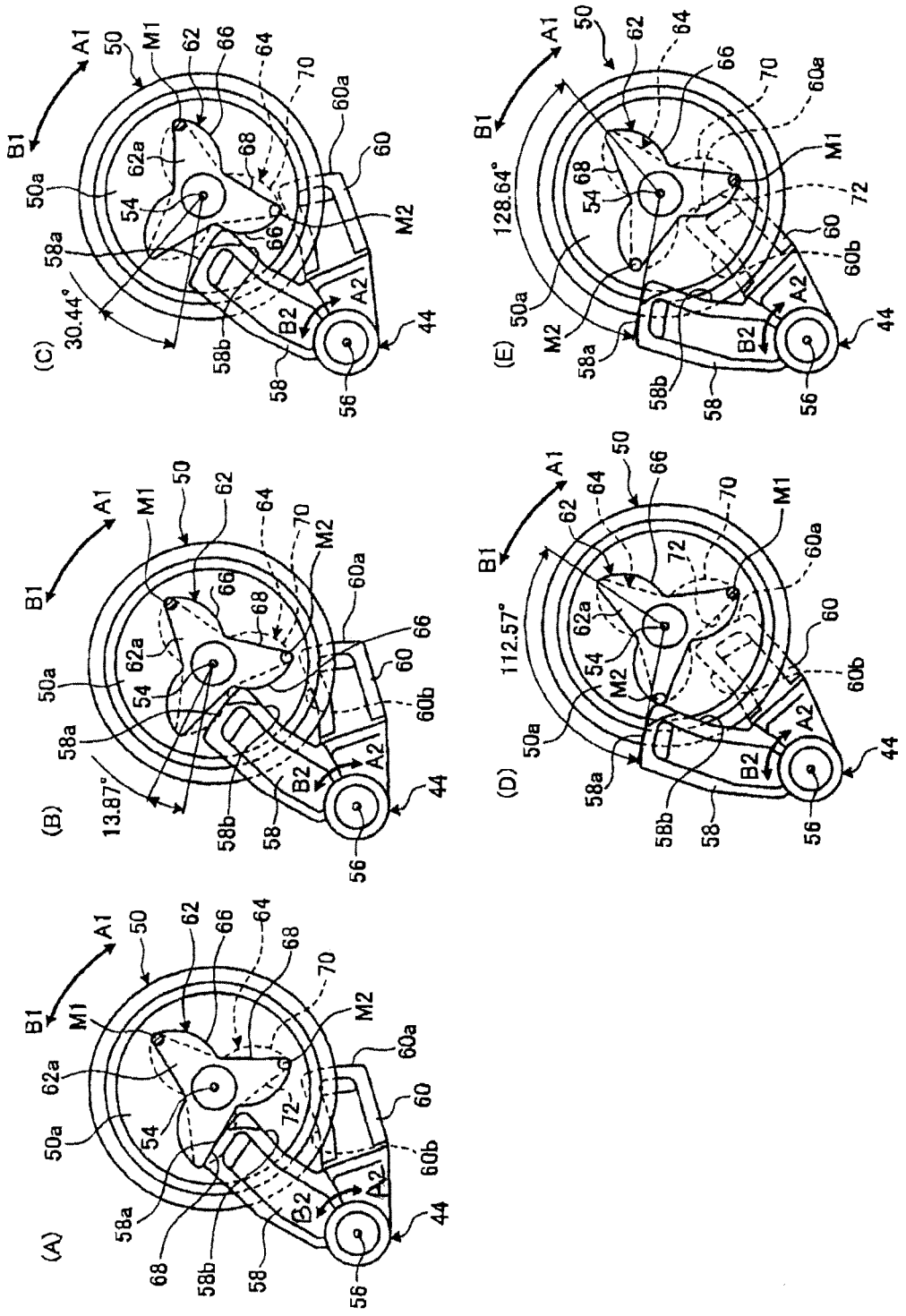
60a
44
84a
C1
C2
C3
C4
t1
t2

FIG. 8


(A)
(B)
(C)
(D)
(E)
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A2
B1
B2
M1
M2
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50a
54
56
58
58a
58b
60
60a
60b
62
62a
64
66
68
70
72
44
30.44°
13.87°
112.57°
128.64°

ACTUATOR UNIT AND DOOR LATCH DEVICE PROVIDED WITH ACTUATOR UNIT

TECHNICAL FIELD

The present invention relates to an actuator unit which shifts a door latch device of a vehicle between a locking state and an unlocking state and the door latch device.

BACKGROUND ART

A door latch device is provided inside a door of a vehicle such as a motor vehicle to hold the door in a closed position. The door latch device can be shifted between a locking state and an unlocking state by driving an actuator unit and operating a manual control means such as a lock knob or the like.

In relation to the above-described actuator unit, the applicant discloses a configuration including a worm wheel which is rotated by a worm secured to a drive shaft of a motor and a lock lever capable of rotating on a shaft center thereof is parallel to a shaft center of the worm wheel in PTLs 1, 2, for example. In this configuration, the worm wheel is rotated by driving the motor, and the lock lever is pressed by projecting portions formed on rotational surfaces of the worm wheel to be shifted between a locking position and an unlocking position, whereby the door latch device connected to the lock lever can be shifted between the locking state and the unlocking state. For example, when the lock lever is shifted from the locking position to the unlocking position, the lock lever is pressed to the unlocking position by the projecting portion formed on one rotational surface of the worm wheel which is driven to rotate by the motor, while the projecting portion formed on the other rotational surface is brought into abutment with the lock lever, whereupon the shifting operation is completed.

Incidentally, in the door latch device, it is necessary to permit a manual operation by a manual control means whether the lock lever is located either in the locking position or in the unlocking position. This requires the actuator unit to be able to rotate only the lock lever between the locking position and the unlocking position wherever the worm wheel stops.

Then, in the case of the actuator unit according to the related art, the projecting portion on each of the rotational surfaces of the worm wheel is configured, for example, so that two tooth portions extend in a 180-degree direction from a rotational center of the worm wheel. Then, a space between both the tooth portions is secured wide, and the projecting portions on both the rotational surfaces have a symmetrical shape. Thus, the manual operation is permitted in an ensured fashion by this configuration.

CITATION LIST

Patent Literature

PTL 1: JP-A-2011-127383
PTL 2: Japanese Patent Publication No. 4754413
PTL 3: Japanese Patent Publication No. 2890842

SUMMARY OF INVENTION

Technical Problem

In recent years, as a so-called smart entry system is propagated, there is a tendency to set short an operation time from the start to end of a locking operation or an unlocking operation. With the related-art door actuator unit described above, however, since the space between the tooth portions which constitute the projecting portion is secured wide, the operation angle of the worm wheel (the projecting portions) through which the lock lever is shifted from the locking position to the unlocking position and is stopped becomes large. When the operation angle of the worm wheel through which the worm wheel rotates for a single operation is large, it is necessary to use a motor having a large output to rotate the worm wheel. Then, when attempting to reduce the operation time by using the large output motor, impact noise generated when the worm wheel stops as a result of the projecting portion being brought into abutment with the lock lever tends to be large. Thus, in order to mitigate the impact, it is necessary that the motor is set in consideration of the balance between the operation time and the impact noise or that an impact absorbing member is placed in the abutment portion between the projecting portions and the lock lever, this calling for an increase in the number of parts involved (refer to PTL 3).

The invention has been made in view of the problem inherent in the related-art actuator unit described above, and an object thereof is to provide an actuator unit which can reduce the operation time of a door latch device without calling for an increase in the number of parts involved.

Solution to Problem

An actuator unit according to the invention includes a drive gear, which is rotatable by driving a motor, and a lock lever, which is rotatable on a predetermined shaft center, the actuator unit being configured to shift a door latch device between a locking state and an unlocking state by rotating the lock lever between a locking position and an unlocking position either by driving the motor or by operating manual control means provided on a door, wherein the drive gear has a first projecting portion, which is formed on a first rotational surface that is one of rotational surfaces on both sides thereof, and a second projecting portion, which is formed on a second rotational surface that is the other rotational surface, wherein the lock lever has a first engagement arm, which is opposed to the first rotational surface of the drive gear so as to be brought into abutment with the first projecting portion, and a second engagement arm, which is opposed to the second rotational surface so as to be brought into abutment with the second projecting portion, wherein the first projecting portion has a pressing surface, which is brought into abutment with the first engagement arm in a first rotational direction of the drive gear, and a locking surface, which is brought into abutment with a rotational end face of the first engagement arm in a second rotational direction which is opposite to the first rotational direction, the pressing surface and the locking surface being provided in a plural number so as to be aligned alternately at intervals along a circumferential direction of the drive gear, wherein the second projecting portion has a pressing surface, which is brought into abutment with the second engagement arm in the second rotational direction of the drive gear, and a locking surface, which is brought into abutment with a rotational end face of the second engagement arm in the first rotational direction, the pressing surface and the locking surface of the second projecting portion being provided in a plural number so as to be aligned alternately at intervals along the circumferential direction of the drive gear, the pressing surface of the second projecting portion being provided back-to-back in relation to the locking surface of the first projecting portion, and the locking surface of the second projecting portion being provided back-to-back in relation to

the pressing surface of the first projecting portion, wherein in a case where the lock lever is in the locking position, when the drive gear is rotated in the second rotational direction by the motor, the pressing surface of the second projecting portion is brought into abutment with the second engagement arm in a rotational direction thereof, whereby the lock lever rotates to the unlocking position, and subsequently, the locking surface of the first projecting portion is brought into abutment with the rotational end face of the first engagement arm, whereby the drive gear stops in a first stop position, wherein in a case where the lock lever is in the unlocking position, when the drive gear is rotated in the first rotational direction by the motor, the pressing surface of the first projecting portion is brought into abutment with the first engagement arm in a rotational direction thereof, whereby the lock lever rotates to the locking position, and subsequently, when the locking surface of the second projecting portion is brought into abutment with the rotational end face of the second engagement arm, whereby the drive gear stops in a second stop position, wherein in a case where the drive gear is in the first stop position, the locking surface of the first projecting portion which is in abutment with the rotational end face of the first engagement arm is situated along an arc-shaped first rotational locus of the rotational end face of the first engagement arm, and the locking surface of the second projecting portion, which is provided back-to-back in relation to the pressing surface of the first projecting portion which follows the locking surface thereof in the first rotational direction, is situated along an arc-shaped second rotational locus of the rotational end face of the second engagement arm which is concentric with the first rotational locus, and wherein in a case where the drive gear is in the second stop position, the locking surface of the second projecting portion which is in abutment with the rotational end face of the second engagement arm is situated along the second rotational locus, and the locking surface of the first projecting portion, which is provided back-to-back in relation to the pressing surface of the second projecting portion which follows the locking surface thereof in the second rotational direction, is situated along the first rotational locus.

According to this configuration, the operation angle of the drive gear when the drive gear is rotated by driving the motor which is defined from the start of the rotation of the first and second projecting portions to the start of the abutment thereof with the first and second engagement arms can be minimized while ensuring the smooth operation of the lock lever during the manual operation. Further, the operation angle of the drive gear through which the locking surface of the first or second projecting portion is brought into abutment with the rotational end face of the first or second engagement arm immediately after the lock lever has been shifted to the locking position or the unlocking position can also be minimized. Because of this, even though a low-output motor is used for the motor, the locking operation and the unlocking operation can be executed in an ensured fashion within the desired operation times, and the impact noise produced when the locking surfaces of the drive gear are brought into abutment with the rotational end faces of the first and second engagement arms can be suppressed.

Herein, in the case where the drive gear is in the first stop position, the pressing surface of the first projecting portion, which follows in the first rotational direction the locking surface of the first projecting portion which is in abutment with the rotational end face of the first engagement arm, intersects an extension of the first rotational locus, and in the case where the drive gear is in the second stop position, the pressing surface of the second projecting portion, which follows in the second rotational direction the locking surface of the second projecting portion which is in abutment with the rotational end face of the second engagement arm, intersects an extension of the second rotational locus. In this case, when adopting a configuration in which, the operation angles of the drive gear when the locking operation and the unlocking operation are executed can be reduced.

Further, the first projecting portion has three first tooth portions which are disposed at equal angular intervals along the circumferential direction of the drive gear, and the pressing surface is provided on an end face of each of the first tooth portions which is oriented in the first rotational direction, while the locking surface is provided on an end face of each of the first tooth portions which is oriented in the second rotational direction, and the second projecting portion has three second tooth portions which are disposed at equal angular intervals along the circumferential direction of the drive gear, and the pressing surface is provided on an end face of each of the second tooth portions which is oriented in the second rotational direction, while the locking surface is provided on an end face of each of the second tooth portions which is oriented in the first rotational direction. When adopting a configuration in which, the operation angles of the drive gear when the locking operation and the unlocking operation are executed can be reduced.

Further, the first projecting portion and the second projecting portion are disposed back-to-back into a symmetrical configuration on both the sides of the drive gear. When adopting a configuration in which, the operation angles of the drive gear when the locking operation and the unlocking operation are executed can be reduced. Further, the overall configuration can be simplified, thereby making it possible to facilitate the control of the locking operation and the unlocking operation.

Advantageous Effects of Invention

According to the invention, the operation angle of the drive gear when the drive gear is rotated by driving the motor which is defined from the start of the rotation of the first and second projecting portions to the start of the abutment thereof with the first and second engagement arms can be minimized while ensuring the smooth operation of the lock lever during the manual operation. Further, the operation angle of the drive gear through which the locking surface of the first or second projecting portion is brought into abutment with the rotational end face of the first or second engagement arm immediately after the lock lever has been shifted to the locking position or the unlocking position can also be minimized. Because of this, even though a low-output motor is used for the motor, the locking operation and the unlocking operation can be executed in an ensured fashion within the desired operation times, and the impact noise produced when the locking surfaces of the drive gear are brought into abutment with the rotational end faces of the first and second engagement arms can be suppressed.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a side view of a door latch device including an actuator unit according to an embodiment of the invention which is seen from an inside of a passenger compartment of a vehicle.

FIG. **2** is a side view showing schematically an interior construction of the door latch device which is in an unlocking state.

FIG. **3** is a side view showing schematically an interior construction of the door latch device which is in a locking state.

FIG. **4** is a perspective view showing a positional relationship between a worm wheel and a lock lever.

FIG. **5** is a front view showing a positional relationship between the worm wheel and the lock lever.

FIG. **6** shows plan views showing relationships between first and second projecting portions and first and second engagement arms in such a state that the lock lever is in an unlocking position, in which FIG. **6**(A) is a plan view as seen from one side of the worm wheel where one rotational surface is located, and FIG. **6**(B) is a plan view as seen from the other side of the worm wheel where the other rotational surface is located.

FIG. **7** shows plan views as seen from the side of the worm wheel where the one rotational surface is located which show the relationships between the first and second projecting portions and the first and second engagement arms, in which FIG. **7**(A) is a plan view showing a state in which the lock lever is in the unlocking position, and FIG. **7**(B) is a plan view showing a state in which the lock lever is in a locking position.

FIG. **8** shows explanatory plan views as seen from the one side of the worm wheel where the one rotational surface is located which show the operations of the worm wheel and the lock lever, in which FIG. **8**(A) is an explanatory plan view showing a state in which the lock lever is in the unlocking position, FIG. **8**(B) is an explanatory plan view showing a state in which a first projecting portion starts to be brought into abutment with the lock lever as a result of a rotation of the worm wheel from the state shown in FIG. **8**(A), FIG. **8**(C) is an explanatory plan view showing a state in which the worm wheel is rotated further from the state shown in FIG. **8**(B) to thereby rotate the lock lever, FIG. **8**(D) is an explanatory plan view showing a state in which the worm wheel is rotated further from the state shown in FIG. **8**(C) to thereby rotate the lock lever further, and FIG. **8**(E) is an explanatory plan view showing a state in which the worm wheel is rotated further from the state shown in FIG. **8**(D) to thereby rotate the lock lever further to be located in the locking position.

DESCRIPTION OF EMBODIMENTS

Hereinafter, an actuator unit according to the invention will be described in detail by reference to the accompanying drawings by taking as an example a preferred embodiment in relation to a door latch device which installs this actuator unit.

FIG. **1** is a side view of a door latch device **12** including an actuator unit **10** according to an embodiment of the invention which is seen from an inside of a passenger compartment of a vehicle and shows a state in which the door latch device **12** is mounted on a door panel of a door D (which is a front side door in FIG. **1**) and is seen from the inside of the passenger compartment. FIG. **2** is a side view showing schematically an interior construction of the door latch device **12** which is in an unlocking state, and FIG. **3** is a side view showing schematically an interior construction of the door latch device **12** which is in a locking state. In the door latch device **12** mounted as shown in FIG. **1**, the left of FIG. **1** denotes the front of the vehicle, the right denoting the rear of the vehicle. However, the orientation of the door latch device **12** may change depending upon a vehicle model in which the door latch device **12** is mounted or a mounting position thereof.

As shown in FIGS. **1** to **3**, the door latch device (the door lock system) **12** includes a meshing unit **14** which is fixed to an inner surface of the door panel which makes up a rear end of an inboard side of the door D with a plurality of bolts (not shown) and which holds and locks the door D in a closed state and the actuator unit **10** which is assembled to the meshing unit **14** and which shifts electrically the door latch device **12** between the locking state and the unlocking state, and the meshing unit **14** and the actuator unit **10** are housed in a lock case **16**.

The meshing unit **14** includes a body **20** which is made up of a body main portion **17** made from a synthetic resin which is fixed to the door D with the bolts and a cover plate portion **18** made of a metal which is fixed to a rear side of the body main portion **17**, and this body **20** is housed within a case **22** which makes up the lock case **16** in such a state that the body **20** is partially exposed. A meshing mechanism **24**, configured to be brought into engagement with a striker (not shown) which is secured to a vehicle body so as to hold the door in a closed state, is housed within a housing space portion which is defined by the body main portion **17** and the cover plate portion **18**, that is, an interior space in the body **20**. A striker entrance groove **26** is provided in the body **20** for entrance of the striker when the door is closed.

A known latch and ratchet mechanism should be used as the meshing mechanism **24**, and in this case, the meshing mechanism **24** has a latch **28** which is supported in a pivotable fashion by a longitudinal shaft (not shown) within the body **20** so as to be brought into engagement with the striker and a ratchet (not shown) which is supported in a pivotable fashion by a longitudinally oriented shaft (not shown) within the body **20** so as to be brought into engagement with or disengagement from the latch **28**. In this meshing mechanism **24**, when the door D is closed, the striker, which is mounted on the vehicle body, enters the striker entrance groove **26** to be brought into engagement with the latch **28**, while the ratchet is brought into engagement with the latch **28** in a direction in which the latch **28** is prevented from rotating in an opening direction thereof, whereby the door D is retained in the closed state. Additionally, by manually operating a key cylinder or a lock knob (a door knob), a door handle or the like, the engagement of the latch **28** with the ratchet is released, whereby the closed state of the door D can be released.

The lock case **16** houses the meshing unit **14** in such a state that the meshing unit **14** is partially exposed. The actuator unit **10** and other constituent parts including various mechanism parts such as levers and a group of connection terminals are housed and disposed in an interior space of the lock case **16**. The lock case **16** includes the case **22**, having substantially an L shape when seen from thereabove and made from a synthetic resin, which is fixed to the body **20**, a cover **30**, made from a synthetic resin, which closes a housing space portion defined within the case **22** and a waterproof cover **32**, made from a synthetic resin, which prevents the infiltration of rain water or the like into the interior of the case **22**. An auxiliary cover **38**, configured to be rotated towards the interior of the passenger compartment on a hinge **36** so as to be opened or closed, is placed at a lower portion of the cover **30**. The auxiliary cover **38** is designed to cover a cable holding portion **40** which is formed at a lower end of the cover **30**. A cable **41** and a cable **42** are provided in the cable holding portion **40**, the cable **41** extending from a lock knob, which is not shown, to be connected to a lock lever **44** which is disposed within the lock case **16**, the cable **42** extending from an inside handle, which is not shown, to be connected to an inside lever **46** which is disposed within the lock case **16**. Reference character S in FIG. **1** denotes a long belt-shaped waterproof seal which is affixed to a passenger compartment-side side surface of the cover **30** so as to prevent the infiltration of rain water or the like into the interior of the passenger compartment.

Next, a specific configuration example of the actuator unit **10** which shifts the door latch device **12** between the locking state and the unlocking state will be described.

As shown in FIGS. **2** and **3**, the actuator unit **10** includes a motor (an electric motor) **48**, a worm wheel **50** and the lock lever **44**, and these constituent parts are housed in the interior of the case **22**.

The motor (the electric motor) **48** can be driven to rotate in an arbitrary direction (a forward or backward direction) according to the direction of an electric current to be supplied, and a worm **52** is secured to a drive shaft **48***a* of the motor **48**. The worm **52** is a cylindrical member having a plurality of thread grooves on an outer circumferential surface thereof, and the worm **52** has, for example, two thread grooves.

The worm wheel (the drive gear) **50** is a circular disc-shaped gear wheel having inclined teeth on an outer circumferential surface thereof. The worm wheel **50** is provided rotatably in the interior of the case **22** in such a state that a shaft center of a support shaft portion **54** which constitutes a rotational center of the worm wheel **50** is at right angles to the drive shaft **48***a* of the motor **48** and that the inclined teeth on the outer circumferential surface are in mesh with the worm **52**.

The lock lever **44** is supported pivotally by a pivot **56** which is placed parallel to the support shaft portion **54** of the worm wheel **50** and is hence provided so as to rotate on a shaft center of the pivot **56** in the interior of the case **22**. The lock lever **44** can rotate, for example, between an unlocking position shown in FIG. **2** and a locking position shown in FIG. **3** where the lock lever **44** rotates in a counterclockwise direction from the unlocking position based on a manual operation of a lock knob which is provided on an inner side of the door D or a key cylinder which is provided on an outer side of the door D, the lock knob and the key cylinder constituting a manual control means, and further a rotation of the worm wheel **50** by driving the motor **48** (the worm **52**). In the lock lever **44**, a cable **41** which is connected to the lock knob is connected to a connecting portion **44***a* which projects in a leftward direction from the pivot **56** in FIGS. **2** and **3**, and various link levers or key levers (not shown) which are connected to the key cylinder are connected to an operating arm portion **44***b* which projects in a rightward direction from the pivot **56**.

Further, a first engagement arm **58** and a second engagement arm **60** which extend from the pivot **56** in centrifugal directions are provided on the lock lever **44**. As shown in FIGS. **4** and **5**, the first engagement arm **58** and the second engagement arm **60** are provided so as not only to be spaced apart from each other in the direction of an axis of the pivot **56** in such a way as to hold rotational surfaces (side surfaces) **50***a*, **50***b* on both sides of the worm wheel **50** therebetween but also to be spaced a predetermined angle apart from each other in relation to a rotational direction of the lock lever **44**.

The first engagement arm (the lever member) **58** extends so as to be close and opposed to the rotational surface **50***a* of the worm wheel **50** and can be brought into abutment with a first projecting portion (a first engagement projecting portion) **62** which is provided on the rotational surface **50***a* (refer to FIG. **6**(A)). On the other hand, the second engagement arm (the lever member) **60** extends so as to be close and opposed to the other rotational surface **50***b* of the worm wheel **50** and can be brought into abutment with a second projecting portion (a second engagement projecting portion) **64** which is provided on the rotational surface **50***b* (refer to FIG. **6**(B)). The first and second engagement arms **58**, **60** are set to such lengths that the first and second engagement arms **58**, **60** do not run across a rotational axis of the worm wheel **50** when the lock lever **44** rotates from the unlocking position to the locking position and in a reverse direction thereto.

The first and second projecting portions **62**, **64** and the first and second engagement arms **58**, **60** constitute together first and second power transmission mechanisms (first and second transmission mechanisms) which transmit the rotation of the worm wheel **50** based on the driving of the motor **48** to the lock lever **44** so as to rotate it, respectively.

In relation to the first and second power transmission mechanisms, firstly, the configurations of the first and second projecting portions **62**, **64** which sit on the worm wheel **50** will be described.

FIG. **6** shows plan views showing relationships between the first and second projecting portions **62**, **64** and the first and second engagement arms **58**, **60** in such a state that the lock lever **44** is in the unlocking position, in which FIG. **6**(A) is a plan view as seen from the side of the worm wheel **50** where the rotational surface **50***a* is located, and FIG. **6**(B) is a plan view as seen from the other side of the worm wheel **50** where the other rotational surface **50***b* is located. Additionally, FIG. **7** shows plan views as seen from the side of the worm wheel **50** where the rotational surface **50***a* is located which show the relationships between the first and second projecting portions **62**, **64** and the first and second engagement arms **58**, **60**, in which FIG. **7**(A) is a plan view showing a state in which the lock lever **44** is in the unlocking position, and FIG. **7**(B) is a plan view showing a state in which the lock lever **44** is in the locking position. In FIGS. **6** and **7**, only main parts of the worm wheel **50** and the lock lever **44** are depicted with the other elements omitted.

The first projecting portion **62** projects above the rotational surface **50***a* of the worm wheel **50** to thereby be brought into abutment with the first engagement arm **58** of the lock lever **44** (refer to FIGS. **5** and **6**(A)). The second projecting portion **64** projects above the other rotational surface **50***b* of the worm wheel **50** to thereby be brought into abutment with the second engagement arm **60** of the lock lever **44** (refer to FIGS. **5** and **6**(B)).

As shown in FIG. **6**(A), the first projecting portion **62** includes three first tooth portions **62***a* each having a substantially triangular shape (a wave-like shape) which projects from the support shaft portion **54** so as to be tapered off radially outwards, and the three first tooth portions **62***a* are provided circumferentially at equal angular intervals about the shaft center of the support shaft portion **54**. In FIG. **6**(A), each first tooth portion **62***a* includes a curved surface (a pressing surface) **66** which constitutes a front end face in a clockwise direction about the support shaft portion **54** and which is curved outwards relative largely and a locking surface (an abutment surface, a stopper surface) **68** which constitutes a rear end face in the clockwise direction and which is curved slightly inwards. For example, the curved surface **66** curves outwards with a first curvature, and the locking surface **68** curves inwards with a second curvature which is smaller than the first curvature. Almost similarly, as shown in FIG. **6**(B), the second projecting portion **64** includes three second tooth portions **64***a* each having a substantially triangular shape which projects from the support shaft portion **54** so as to be tapered off radially outwards, and the three second tooth portions **64***a* are provided circumferentially at equal angular intervals about the shaft center of the support shaft portion **54**. In FIG. **6**(B), each second tooth portion **64***a* includes a curved surface (a pressing surface) **70** which constitutes a front end face in the clockwise direction about the support shaft portion **54** and which is curved outwards relative largely and a locking surface (an abutment surface, a stopper surface) **72** which

constitutes a rear end face in the clockwise direction and which is curved slightly inwards.

As is understood from FIGS. **6**(A) and **6**(B), the first and second projecting portions **62**, **64** are provided so as to project axially outwards of the support shaft portion **54** on the rotational surfaces **50***a*, **50***b* on both the sides of the worm wheel **50** and are disposed back-to-back in relation to the rotational surfaces **50***a*, **50***b* of the worm wheel **50** in a symmetrical (axially symmetrical) fashion. In other words, the first and second projecting portions **62**, **64** are formed into an orthogonally symmetrical relationship with respect to an imaginary plane P (refer to FIG. **5**) which includes the thickness center line of the worm wheel **50** and is at right angles to the support shaft portion **54** (a symmetrical relationship with respect to the plane P).

Consequently, a specific first tooth portion **62***a* and a specific second tooth portion **64***a* are disposed so as to overlap generally each other when seen from the side of the worm wheel **50** where the rotational surface **50***a* is located as shown in, for example, FIG. **6**(A), and the specific first and second tooth portions **62***a*, **64***a* are disposed so that the curved surface **70** of the second tooth portion **64***a* corresponds to the locking surface **68** of the first tooth portion **62***a* (in a back-to-back fashion), while the locking surface **72** of the second tooth portion **64***a* corresponds to the curved surface **66** of the first tooth portion **62***a* (in a back-to-back fashion).

Next, the configurations of the first and second engagement arms **58**, **60** which sit on the lock lever **44** will be described.

When it is seen from thereabove as in FIG. **6**, the first engagement arm **58** curves slightly towards the second engagement arm **60** halfway outwards its extension while extending from the pivot **56** in a centrifugal direction and has a rotational end face (a distal end face) **58***a* which curves slightly so as to follow an arc which is centered at the pivot **56** at an outer distal end edge thereof. When it is seen from thereabove as in FIG. **6**, the second engagement arm **60** curves slightly towards the first engagement arm **58** halfway outwards its extension while extending from the pivot **56** in the centrifugal direction and has a rotational end face (a distal end face) **60***a* which curves slightly so as to follow an arc which is centered at the pivot **56** at an outer distal end edge thereof.

In the first and second power transmission mechanisms described above, for example, as shown in FIGS. **2** and **7**(A), when the lock lever **44** is in the unlocking position, the first engagement arm **58** of the lock lever **44** is situated within a rotational locus of the first projecting portion **62** of the worm wheel **50**, and the second engagement arm **60** is situated outside a rotational locus of the second projecting portion **64** of the worm wheel **50**, and additionally, the locking surface **68** of the specific first tooth portion **62***a* is in abutment with or close to the rotational end face **58***a* of the first engagement arm **58**. Hereinafter, as shown in FIGS. **2** and **7**(A), a position (an angular position) of the worm wheel **50** resulting when the lock lever **44** is in the unlocking position and the door latch device **12** is in the unlocking state will be called a first stop position (a first angular position).

In this state, a curved surface **66** of a first tooth portion **62***a* which lies adjacent to the specific first tooth portion **62***a* is situated in a position which lies adjacent to a corner portion of the rotational end face **58***a* of the first engagement portion **58**, that is, for example, in a position which is spaced by a slight gap t**1** away form the corner portion of the rotational end face **58***a* (refer to FIG. **7**(A)). Further, in this state, as shown in FIG. **7**(A), at least part of the locking face **68** of the specific first tooth portion **62***a* is situated on an arc C**1** which is centered at the shaft center of the pivot **56** of the lock lever **44**. Additionally, at least part of the locking surface **72** of the second tooth portion **64***a* of the second projecting portion **64** which corresponds to the first tooth portion **62***a* which has the curved surface **66** which lies in the position which is spaced by the gap t**1** away from the rotational end face **58***a* of the first engagement arm **58** is situated on an arc C**2** which is centered at the shaft center of the pivot **56** of the lock lever **44**. Namely, the arc C**1** and the arc C**2** are concentric circles which are centered at the pivot **56**, and the locking surfaces **68** of the first projecting portion **62** and the locking surfaces **72** of the second projecting portion **64** are situated on the concentric circles. Additionally, in this embodiment, as shown in FIG. **7**(A), the rotational end face **58***a* of the first engagement arm **58** rotates along the arc C**1**, and the rotational end face **60***a* of the second engagement arm **60** rotates along the arc C**2**. In other words, when the worm wheel **50** is in the first stop position, the locking surface **68** of the specific first tooth portion **62***a* which is brought into abutment with the rotational end face **58***a* of the first engagement arm **58** and the locking surface **72** of the second tooth portion **64***a* which lies adjacent to the specific first tooth portion **62***a* and corresponds to the first tooth portion **62***a* which has the curved surface **66** which is situated in the position which is spaced by the gap t**1** away from the rotational end face **58***a* of the first engagement arm **58** are situated along the rotational loci of the rotational end face **58***a* of the first engagement portion **58** and the rotational end face **60***a* of the second engagement arm **60** which are concentric with each other.

When a key cylinder or a lock knob is operated, as shown in FIGS. **3** and **7**(B), the lock lever **44** rotates through a predetermined angle in a locking direction (a counterclockwise direction in FIG. **7**(B)) from the unlocking position shown in FIGS. **2** and **7**(A) and stops in the locking position.

Here, as described above, when the worm wheel **50** is in the first stop position shown in FIG. **7**(A), the locking surface **68** of the first projecting portion **62** and the locking surface **72** of the second projecting portion **64** are situated on the concentric circles as shown in FIGS. **3** and **7**(B). Because of this, as shown in FIG. **7**(A), the first projecting portion **62** of the worm wheel **50** which stays stationary in the first stop position is situated outside the rotational locus of the rotational end face **58***a* of the first engagement arm **58** of the lock lever **44**. Further, the second projecting portion **64** of the worm wheel **50** which stays stationary in the first stop position is situated outside the rotational locus of the rotational end face **60***a* of the second engagement arm **60** of the lock lever **44**. Because of this, even though the lock lever **44** rotates from the unlocking position to the locking position with the worm wheel **50** staying stationary in the first stop position, the first and second engagement arms **58**, **60** are never brought into abutment with the first and second projecting portions **62**, **64** to press them although the first and second engagement arms **58**, **60** may be brought into sliding contact with the first and second projecting portions **62**, **64**. Thus, even though the lock lever **44** is rotated by the manual operation, the worm wheel **50** is prevented from rotating in association with the rotation of the lock lever **44**. Consequently, the rotation of the worm wheel **50** or the motor **48** based on the locking operation of the key cylinder and the lock knob is prevented. This reduces the resistance produced at the time of locking operation, whereby the locking operation can be performed with a light force. Further, this can prevent the motor **48** from rotating reversely to thereby prevent the deterioration of the motor **48** which would otherwise be caused by the reverse rotation of the motor **48** as a generator.

Moreover, the curved surface **66** of the first tooth portion **62***a* which lies adjacent to the first tooth portion **62***a* having

the locking surface **68** which is in abutment with or close to the rotational end face **58***a* of the first engagement arm **58** is disposed close to the first engagement arm **58** via the slight gap t**1** in such a state that the worm wheel **50** stays stationary in the first stop position. Because of this, even though the worm wheel **50** attempts to rotate excessively due to an overrun or the like which occurs immediately after the lock lever **44** is rotated from the locking position to the unlocking position by rotationally driving the worm wheel **50**, which will be described later, a forward rotation of the worm wheel **50** is prevented by the engagement between the rotational end face **58***a* of the first engagement arm **58** and the locking surface **68**. Further, a reverse rotation of the worm wheel **50** is restricted to a slight rotational angle by the abutment of the corner portion of the rotational end face **58***a* of the first engagement arm **58** with the curved surface **66** via the gap t**1**. Consequently, since the worm wheel **50** stops in the first stop position, the resistance at the time of locking operation can be reduced.

On the other hand, as shown in FIGS. **3** and **7**(B), when the lock lever **44** is in the locking position, the first engagement arm **58** of the lock lever **44** is situated outside the rotational locus of the first projecting portion **62** of the worm wheel **50**, and the second engagement arm **60** is situated within the rotational locus of the second projecting portion **64** of the worm wheel **50**. Additionally, the locking surface **72** of the specific second tooth portion **64***a* is in abutment with or close to the rotational end face **60***a* of the second engagement arm **60**. Hereinafter, as shown in FIGS. **3** and **7**(B), a position (an angular position) of the worm wheel **50** resulting when the lock lever **44** is in the locking position and the door latch device **12** is in the locking state will be called a second stop position (a second angular position).

Substantially similar to the case where the door latch device **12** is in the unlocking state as described above, in this state, a curved surface **70** of a second tooth portion **64***a* which lies adjacent to the specific second tooth portion **64***a* is situated in a position which lies adjacent to a corner portion of the rotational end face **60***a* of the second engagement arm **60**, that is, for example, a position which is spaced by a slight gap t**2** away from the corner portion of the rotational end face **60***a* (refer to FIG. **7**(B)). Further, in this state, too, as shown in FIG. **7**(B), at least part of the locking surface **72** of the specific second tooth portion **64***a* is situated on an arc C**3** which is centered at the shaft center of the pivot **56** of the lock lever **44**. Additionally, at least part of the locking surface **68** of the first tooth portion **62***a* of the first projecting portion **62** which corresponds to the second tooth portion **64***a* which has the curved surface **70** which is situated in the position which is spaced by the gap t**2** away from the rotational end face **60***a* of the second engagement arm **60** is situated on an arc C**4** which is centered at the shaft center of the pivot **56** of the lock lever **44**. Namely, the arc C**3** and the arc C**4** are concentric circles which are centered at the pivot **56**, and the locking surfaces **72** of the second projecting portion **64** and the locking surfaces **68** of the first projecting portion **62** are situated on the concentric circles. Additionally, in this embodiment, as shown in FIG. **7**(B), the rotational end face **58***a* of the first engagement arm **58** rotates along the arc C**4**, and the rotational end face **60***a* of the second engagement arm **60** rotates along the arc C**4**. In other words, when the worm wheel **50** is in the second stop position, the locking surface **72** of the specific second tooth portion **64***a* which is brought into abutment with the rotational end face **60***a* of the second engagement arm **60** and the locking surface **68** of the first tooth portion **62***a* which lies adjacent to the specific second tooth portion **64***a* and corresponds to the second tooth portion **64***a* which has the curved surface **70** which is situated in the position which is spaced by the gap t**2** away from the rotational end face **60***a* of the second engagement arm **60** are situated along the rotational loci of the rotational end face **58***a* of the first engagement arm **58** and the rotational end face **60***a* of the second engagement arm **60** which are concentric with each other.

In this embodiment, since the first projecting portion **62** and the second projecting portion **64** are disposed back-to-back into the symmetrical configuration, the gap t**1** and the gap t**2** are the same, the arc C**1** and the arc C**3** have the same diameter, and the arc C**2** and the arc C**4** have the same diameter.

When the key cylinder or the lock knob is operated from the locking position shown in FIGS. **3** and **7**(B) to unlock the door D, as shown in FIGS. **2** and **7**(A), the lock lever **44** rotates through a predetermined angle in an unlocking direction (a clockwise direction in FIG. **7**(A)) and then stops in the unlocking position.

In this case, too, the worm wheel **50** stays stationary in the second stop position shown in FIG. **7**(B), and the locking surface **68** of the first projecting portion **62** and the locking surface **72** of the second projecting portion **64** are situated on the concentric circles. Because of this, as shown in FIG. **7**(B), the first projecting portion **62** of the worm wheel **50** which stays stationary in the second stop position is situated outside the rotational locus of the rotational end face **58***a* of the first engagement arm **58** of the lock lever **44**. Further, the second projecting portion **64** of the worm wheel **50** which stays stationary in the second stop position is situated outside the rotational locus of the rotational end face **60***a* of the second engagement arm **60** of the lock lever **44**. Consequently, even though the lock lever **44** is rotated from the locking position to the unlocking position by the manual operation with the worm wheel **50** staying stationary in the second stop position, the first and second engagement arms **58**, **60** are never brought into abutment with the first and second projecting portions **62**, **64** to press them although the first and second engagement arms **58**, **60** may be brought into sliding contact with the first and second projecting portions **62**, **64**. Thus, even though the lock lever **44** is rotated by the manual operation, the worm wheel **50** is prevented from rotating in association with the rotation of the lock lever **44**.

In addition, also in such a state that the worm wheel **50** stays stationary in the second stop position, the curved surface **70** of the second tooth portion **64***a* which lies adjacent to the second tooth portion **64***a* having the locking surface **72** which is in abutment with (or close to) the rotational end face **60***a* of the second engagement arm **60** is disposed close to the second engagement arm **60** via the slight gap t**2**. Because of this, substantially similar to the case where the worm wheel **50** stays stationary in the first stop position, even though the worm wheel **50** attempts to rotate excessively due to the overrun or the like which occurs immediately after the lock lever **44** is rotated by rotationally driving the worm wheel **50**, a forward and reverse rotations of the worm wheel **50** are prevented by the locking surface **72** and the curved surface **70**, the worm wheel **50** stays stationary in the second stop position in an ensured fashion and this can reduce the resistance at the time of locking operation.

Next, referring mainly to FIG. **8**, electric shifting operations of the door latch device **12** between the unlocking state and the locking state by rotating the worm wheel **50** by driving the motor **48** and rotating the lock lever **44** from the unlocking position to the locking position will be described.

FIG. **8** shows explanatory plan views as seen from the one side of the worm wheel **50** where the rotational surface **50***a* is located which show the operations of the worm wheel **50** and

the lock lever **44**, in which FIG. **8**(A) is an explanatory plan view showing a state in which the lock lever **44** is in the unlocking position, FIG. **8**(B) is an explanatory plan view showing a state in which the first projecting portion **62** starts to be brought into abutment with the lock lever **44** as a result of a rotation of the worm wheel **50** from the state shown in FIG. **8**(A), FIG. **8**(C) is an explanatory plan view showing a state in which the worm wheel **50** is rotated further from the state shown in FIG. **8**(B) to thereby rotate the lock lever **44**, FIG. **8**(D) is an explanatory plan view showing a state in which the worm wheel **50** is rotated further from the state shown in FIG. **8**(C) to thereby rotate the lock lever **44** further, and FIG. **8**(E) is an explanatory plan view showing a state in which the worm wheel **50** is rotated further from the state shown in FIG. **8**(D) to thereby rotate the lock lever **44** further to be located in the locking position. In FIG. **8**, only the main parts of the worm wheel **50** and the lock lever **44** are shown with the other elements omitted. However, when the lock lever **44** is shifted from the unlocking position to the locking position, the aforesaid link levers or key levers are operated accordingly in association with the shifting of the lock lever **44**, and the door latch device **12** is shifted between the unlocking state and the locking state. In addition, in FIG. **8**, to clearly show a relationship between the rotational angle of the first projecting portion **62** and the rotational position of the lock lever **44** which are determined based on the rotation of the worm wheel **50**, a mark M1 is given to a distal end of one of the three first tooth portions **62***a* which make up the first projecting portion **62**, and a mark M2 is given to another of the three first tooth portions **62***a*.

Firstly, a locking operation will be described in which the lock lever **44** is rotated from the unlocking position to the locking position.

As shown in FIG. **8**(A), when the lock lever **44** is in the unlocking position, for example, it means that the lock lever **44** has rotated in the clockwise direction to stop in that position, and the rotational end face **58***a* of the first engagement arm **58** is in abutment with (or close to) the locking surface **68** of the specific first tooth portion **62***a* of the first projecting portion **62** of the worm wheel **50** which stays stationary in the first stop position.

In this state, when a control switch provided inside a passenger compartment or a portable control switch is operated to lock the door D, the motor **48** rotates in the locking direction, whereby the worm wheel **50** rotates in the locking direction (the clockwise direction, that is, a direction indicated by an arrow A1) from the position shown in FIG. **8**(A). As shown in FIG. **8**(B), when the worm wheel **50** has rotated through 13.87°, for example, the curved surface **66** of the first tooth portion **62***a* which follows the locking surface **68** of the specific first tooth portion **62***a* in the locking direction starts to be brought into abutment with the corner portion of the rotational end face **58***a* of the first engagement arm **58** (an upper portion of an inner surface **58***b* which forms an inner surface of an outer edge of the first engagement arm **58**). When the worm wheel **50** rotates further in the locking direction, as shown in FIG. **8**(C), the curved surface **66** of the first tooth portion **62***a* presses against the lock lever **44** while in slicing contact with the upper portion of the inner surface **58***b* of the first engagement arm **58**, whereby the lock lever **44** rotates in the locking direction (the counterclockwise direction, a direction indicated by an arrow B2). When the worm wheel **50** continues to rotate in the locking direction as shown in FIG. **8**(D), the lock lever **44** rotates further largely in the locking direction.

Finally, as shown in FIG. **8**(E), when the worm wheel **50** rotates through, for example, 128.46°, the first engagement arm **58** goes out of the rotational locus of the first projecting portion **62**, and the lock lever **44** stops in the locking position. Subsequently, the second engagement arm **60** enters the rotational locus of the second projecting portion **64**, and the locking surface **72** of the second projecting portion **64** of the worm wheel **50** is brought into abutment with the rotational end face **60***a* of the second engagement arm **60**. This stops the rotation of the worm wheel **50**, and the worm wheel **50** stops in the second stop position, whereby the shifting operation of the lock lever **44** to the locking position is completed, which puts the door latch device **12** in the locking state.

Next, an unlocking operation will be described in which the lock lever **44** is rotated from the locking position to the unlocking position.

This unlocking operation proceeds in a reverse direction to the locking operation described above. As shown in FIG. **8**(E), when the lock lever **44** is in the locking position, it means that the lock lever **44** has rotated in the counterclockwise direction and stops there, and the rotational end face **60***a* of the second engagement arm **60** is in abutment with (or close to) the locking surface **72** of the specific second tooth portion **64***a* of the second projecting portion **64** of the worm wheel **50** which stays stationary in the second stop position.

In this state, when the control switch provided inside the passenger compartment or the portable control switch is operated to unlock the door D, the motor **48** rotates in the unlocking direction, whereby the worm wheel **50** rotates in the unlocking direction (the counterclockwise direction, that is, a direction indicated by an arrow B1) from the position shown in FIG. **8**(E). Then, as shown in FIG. **8**(D), the curved surface **70** of the second tooth portion **64***a* which follows the locking surface **72** of the specific second tooth portion **64***a* in the unlocking direction starts to be brought into abutment with the corner portion of the rotational end face **60***a* of the second engagement arm **60** (an upper portion of an inner surface **60***b* which forms an inner surface of an outer edge of the second engagement arm **60**). When the worm wheel **50** rotates further in the unlocking direction, as shown in FIGS. **8**(C) and **8**(B), the curved surface **70** of the second tooth portion **64***a* presses the lock lever **44** to rotate it while in sliding contact with the upper portion of the inner surface **60***b* of the second engagement arm **60**, and this rotates the lock lever **44** in the unlocking direction (the clockwise direction, that is, a direction indicated by an arrow A2).

Finally, as shown in FIG. **8**(A), when the worm wheel **50** rotates, for example, through 128.46° in the reverse direction to the locking operation, the second engagement arm **60** goes out of the rotational locus of the second projecting portion **64**, and the lock lever **44** stops in the unlocking position. Subsequently, the first engagement arm **58** enters the rotational locus of the first projecting portion **62**, and the locking surface **68** of the first projecting portion **62** of the worm wheel **50** is brought into engagement with the rotational end face **58***a* of the first engagement arm **58**. This stops the rotation of the worm wheel **50**, and the worm wheel **50** stops in the first stop position, whereby the shifting of the lock lever **44** to the unlocking position is completed, and this puts the door latch device **12** in the unlocking state.

In this way, when the lock lever **44** is shifted from the unlocking position to the locking position or from the locking position to the unlocking position by the rotation of the worm wheel **50**, for example, in the actuator unit of PTL 1 described above, the operation angle through which the projecting portions of the worm wheel come into abutment with the engagement arms of the lock lever is large and is set to about 230°, for example. Because of this, it is necessary that the high-output motor is used to reduce the operation time, however, the large

impact noise is produced when the projecting portions of the worm wheel are brought into abutment with the rotational end faces of the engagement arms. Then, in order to absorb the impact noise, it is necessary that the impact noise absorbing member is set between the rotational end faces of the engagement arms and the projecting portions of the worm wheel (refer to PTL 3).

In contrast with this conventional actuator unit, in the actuator unit **10** according to this embodiment, as shown in FIG. **7**, when the worm wheel **50** is in the first stop position and the second stop position, the locking surface **68** of the first projecting portion **62** and the locking surface **72** of the second projecting portion **64** are situated along the rotational locus of the first engagement arm **58** and the rotational locus of the second engagement arm **60** of the lock lever **44** and are situated on the concentric circles which are centered at the shaft center of the pivot **56** of the lock lever **44**.

By adopting this configuration, in the actuator unit **10**, in the unlocking position shown in FIG. **7**(A) and the locking position shown in FIG. **7**(B), the curved surfaces **66**, **70** of the first and second tooth portions **62***a*, **64***a* which lie adjacent to the specific first and second tooth portions **62***a*, **64***a* which are in abutment with (or close to) the first engagement arm **58** and the second engagement arm **60** are set in the positions which are spaced the slight gaps t**1**, t**2** away therefrom. In particular, in this embodiment, as shown in FIGS. **7**(A) and **7**(B), the curved surfaces **66**, **70** of the first and second tooth portions **62***a*, **64***a* set so as to intersect extensions of the rotational loci of the first engagement arm **58** and the second engagement arm **60**. Thus, the curved surfaces **66**, **70** of the first and second tooth portions **62***a*, **64***a* which lie adjacent to the specific ones start to be brought into abutment with the inner surfaces **58***b*, **60***b* of the first and second engagement arms **58**, **60** of the lock lever **44** immediately after the worm wheel **50** starts to rotate as shown in FIG. **8**(B) when the locking operation is performed and as shown in FIG. **8**(D) when the unlocking operation is performed. Moreover, for example, when the locking operation is performed, the first engagement arm **58** is kicked out largely to go out of the rotational locus of the first projecting portion **62** by the curved surface **66** of the first projecting portion **62** as shown in FIG. **8**(D). As this occurs, the locking surface **68** of the first projecting portion **62** which follows the curved surface **66** thereof has already been situated almost along the rotational locus of the first engagement arm **58** and the locking surface **72** of the second projecting portion **64** has been close to the rotational end face **60***a* of the second engagement arm **60** on the side of the worm wheel **50** which constitutes a rear side thereof. Thus, the rotational end face **60***a* and the locking surface **72** are brought into abutment with each other without any delay, whereupon the locking operation is completed (refer to FIG. **8**(E)). The unlocking operation is performed substantially in a similar way. Consequently, the operation angle of the lock lever **44** from the start of the unlocking operation or the locking operation to the start of the rotation of the lock lever **44** and further to the stop of the rotation of the lock lever **44** can be shortened. Thus, even though a low-output motor is used for the motor **48**, the locking operation and the unlocking operation can be performed within desired operation times in an ensured fashion, and impact noise produced when the locking surfaces **68**, **72** are brought into abutment with the rotational end faces **58***a*, **60***a* can be reduced.

Additionally, in the actuator unit **10** of this embodiment, for example, when the locking operation is performed, as shown in FIG. **8**(B), the lock lever **44** starts to rotate when the worm wheel **50** has rotated through about 13.87° since the start of its rotation and stops rotating when the worm wheel **50** has rotated through about 128.46°, while in the actuator unit of PTL 1 described above, the lock lever starts to rotate when the worm wheel has rotated through about 64° and stops rotating when the worm wheel has rotated through about 230°. Thus, the difference between the operation angles of the two actuator units becomes large.

Further, in the actuator unit **10** of this embodiment, the locking surfaces **68** of the first projecting portion **62** and the locking surfaces **72** of the second projecting portion **64** are situated on the concentric circles which are centered at the shaft center of the pivot **56** of the lock lever **44**, whereby although the locking operation and the unlocking operation are ensured within the small operation angles described above, as shown in FIGS. **7**(A) and **7**(B), in such a state that the lock lever **44** stays in the unlocking position or the locking position while the worm wheel **50** stays stationary in the first stop position or the second stop position, the first and second projecting portions **62**, **64** of the worm wheel **50** are not situated on the rotational loci of the first and second engagement arms **58**, **60** of the lock lever **44**. By adopting this configuration, when the lock knob or the key cylinder which makes up the manual control means is operated manually, the worm wheel **50** is never drawn by the lock lever **44**, whereby the lock lever **44** is permitted to rotate between the unlocking position and the locking position smoothly.

In this embodiment, the locking surfaces **68**, **72** are described as being situated at least partially on the concentric circles, and this means that the locking surfaces **68**, **72** should be formed so that outlines of the locking surfaces **68**, **72** follow at least partially the arcs C**1**, C**2**, C**3**, C**4** in plan views shown in FIG. **7**, and hence, the locking surfaces **68**, **72** do not have to be situated on the concentric circles along the full length of their outlines. In other words, in consideration of achieving the smooth rotational operations of the first and second engagement arms **58**, **60** during the manual unlocking or locking operation, it is preferable that recess portions are formed at side portions of the locking surfaces **68**, **72** for facilitating the escape of the rotational end faces **58***a*, **60***a* when the first and second engagement arms **58**, **60** rotate.

It is noted that the invention is not limited to the embodiment that has been described heretofore and can, of course, be modified freely without departing from the spirit and scope of the invention.

For example, in the embodiment, while the first and second projecting portions **62**, **64** of the worm wheel **50** are described as each having the three first and second tooth portions **62***a*, **64***a*, the number of first and second tooth portions **62***a*, **64***a* may, of course, be four or more. In short, the locking surfaces **68**, **72** of the specific first and second tooth portions **62***a*, **64***a* should be configured so as to be at least partially situated on the concentric circles when the worm wheel **50** stays stationary in the first stop position and the second stop position.

INDUSTRIAL APPLICABILITY

According to the invention, it is possible to provide the actuator unit which can shorten the operation time of the door latch device without calling for the increase in the number of parts involved.

While the invention has been described in detail and by reference to the specific embodiment, it is obvious to those skilled in the art to which the invention pertains that various alterations or modifications can be made thereto without departing from the spirit and scope of the invention. This patent application is based on Japanese Patent Application

(No. 2012-086627) filed on Apr. 5, 2012, the contents of which are incorporated herein by reference.

REFERENCE SIGNS LIST

10 Actuator unit
12 Door latch device
44 Lock lever
48 Motor
50 Worm wheel
50*a*, **50***b* Rotational surface
52 Worm
54 Support shaft portion
56 Pivot
58 First engagement arm
58*a*, **60***a* Rotational end face
60 Second engagement arm
62 First projecting portion
62*a* First tooth portion
64 Second projecting portion
64*a* Second tooth portion
68, **72** Locking surface.

The invention claimed is:

1. An actuator unit comprising a drive gear, which is rotatable by a motor, and a lock lever, which is rotatable on a predetermined shaft center, the actuator unit being configured to shift a door latch device between a locking state and an unlocking state by rotating the lock lever between a locking position and an unlocking position either by driving the motor or by operating manual control means provided on a door,

wherein the drive gear has a first projecting portion, which is formed on a first rotational surface that is one of rotational surfaces on either side of the drive gear, and a second projecting portion, which is formed on a second rotational surface that is the other rotational surface of the rotational surfaces on either side of the drive gear,

wherein the lock lever has a first engagement arm, which is opposed to the first rotational surface of the drive gear so as to be brought into abutment with the first projecting portion, and a second engagement arm, which is opposed to the second rotational surface so as to be brought into abutment with the second projecting portion,

wherein the first projecting portion has pressing surfaces, a first one of which is brought into abutment with the first engagement arm in a first rotational direction of the drive gear, and locking surfaces, a first one of which is brought into abutment with a rotational end face of the first engagement arm in a second rotational direction which is opposite to the first rotational direction, the pressing surfaces and the locking surfaces being provided so as to be aligned alternately at intervals along a circumferential direction of the drive gear,

wherein the second projecting portion has pressing surfaces, a first one of which is brought into abutment with the second engagement arm in the second rotational direction of the drive gear, and locking surfaces, a first one of which is brought into abutment with a rotational end face of the second engagement arm in the first rotational direction, the pressing surfaces and the locking surfaces of the second projecting portion being provided so as to be aligned alternately at intervals along the circumferential direction of the drive gear, each of the pressing surfaces of the second projecting portion being provided in back-to-back relation to a corresponding one of the locking surfaces of the first projecting portion, and each of the locking surfaces of the second projecting portion being provided in back-to-back relation to a corresponding one of the pressing surfaces of the first projecting portion,

wherein in a case where the lock lever is in the locking position, when the drive gear is rotated in the second rotational direction by the motor, the first pressing surface of the second projecting portion is brought into abutment with the second engagement arm, whereby the lock lever rotates to the unlocking position, and subsequently, the first locking surface of the first projecting portion is brought into abutment with the rotational end face of the first engagement arm, whereby the drive gear stops in a first stop position,

wherein in a case where the lock lever is in the unlocking position, when the drive gear is rotated in the first rotational direction by the motor, the first pressing surface of the first projecting portion is brought into abutment with the first engagement arm, whereby the lock lever rotates to the locking position, and subsequently, the first locking surface of the second projecting portion is brought into abutment with the rotational end face of the second engagement arm, whereby the drive gear stops in a second stop position,

wherein in a case where the drive gear is in the first stop position, the first locking surface of the first projecting portion which is in abutment with the rotational end face of the first engagement arm is situated along an arc-shaped first rotational locus of the rotational end face of the first engagement arm, and the first locking surface of the second projecting portion, which is provided in back-to-back relation to the first pressing surface of the first projecting portion which follows the locking surface thereof in the first rotational direction, is situated along an arc-shaped second rotational locus of the rotational end face of the second engagement arm which is concentric with the first rotational locus, and

wherein in a case where the drive gear is in the second stop position, the first locking surface of the second projecting portion which is in abutment with the rotational end face of the second engagement arm is situated along the second rotational locus, and the first locking surface of the first projecting portion, which is provided in back-to-back relation to the first pressing surface of the second projecting portion which follows the first locking surface of the second projecting portion in the second rotational direction, is situated along the first rotational locus.

2. The actuator unit according to claim **1**,

wherein in the case where the drive gear is in the first stop position, the first pressing surface of the first projecting portion, which follows in the first rotational direction the first locking surface of the first projecting portion which is in abutment with the rotational end face of the first engagement arm, intersects an extension of the first rotational locus, and

wherein in the case where the drive gear is in the second stop position, the first pressing surface of the second projecting portion, which follows in the second rotational direction the first locking surface of the second projecting portion which is in abutment with the rotational end face of the second engagement arm, intersects an extension of the second rotational locus.

3. The actuator unit according to claim **1**,

wherein the first projecting portion has three first tooth portions which are disposed at equal angular intervals along the circumferential direction of the drive gear, and each of the pressing surfaces is provided on an end face

of each of the first tooth portions so as to be oriented towards the first rotational direction, while each of the locking surfaces is provided on an end face of each of the first tooth portions so as to be oriented towards the second rotational direction, and

wherein the second projecting portion has three second tooth portions which are disposed at equal angular intervals along the circumferential direction of the drive gear, and each of the pressing surfaces is provided on an end face of each of the second tooth portions so as to be oriented towards the second rotational direction, while each of the locking surfaces is provided on an end face of each of the second tooth portions so as to be is oriented towards the first rotational direction.

4. The actuator unit according to claim **1**, wherein the first projecting portion and the second projecting portion are disposed back-to-back into a symmetrical configuration on either side of the drive gear.

5. A door latch device, characterized by comprising the actuator unit according to claim **1**.

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